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Programed instruction is seen as a complete system of teaching, organized and designed to meet the specific objective of efficient individual learning. Its methods provide the means for resolving the broad scope of instructional requirements which include the need for both individual and group instruction. The systems approach concept, originally related to weapons systems, is applied to programed instruction. It requires defining the job of each person working together to achieve a common goal, detailing his tasks, specifying performance requirements, and stating the necessary interactions and communications to be carried out between groups.

Three scopes of activity, performed by independent groups, are defined and analyzed. They are: the curriculum director and the programer, who analyze and develop instructional materials; the teachers and students who carry out the methods and procedures in the instructional process; and the administrative, supervisory, and parental groups who, operating outside the immediate instructional environment, directly or indirectly influence the quality of instruction and individual learning.

In addition to postulating system requirements, examples of their application to accomplish optimal design of instructional sequences in existing instructional environments are given.

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To: Dr. Jim Finn
Would appreciate your comments after you are finished!
Bob

PROGRAMMED INSTRUCTION AS A SYSTEMS APPROACH TO EDUCATION

An Invitational Address Presented at the
National Society for Programmed Instruction
March 27, 1963, San Antonio, Texas

BY

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INSTRUCTIONAL TECHNOLOGY . U.S.C.

INTRODUCTION

During the past three years programmed instructional methods have been extensively explored and evaluated at all levels within our national educational system. The results substantiate the positive significance of these methods for education.

While educators acknowledge the significance of self-instructional programming methods, they are posing penetrating questions concerning the application of programmed instruction to the broader scope of instructional requirements which face them.

A specific realism expressed by the educator is the requirement for both individual and group instruction.

Dr. J. Lloyd Trump, National Education Association, presents a plan of action which recommends that 60% of the average 30 hour week be utilized for large and small group instruction, and 40% for individual instruction. His report, and others, emphasizes the group or class as the basic instructional unit in our educational system --- at least for the foreseeable future.

Our concern in group instruction is that each individual within the group attain his greatest potential level of achievement, by our providing instructional and individual learning conditions to insure this.

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Educators are Asking These Questions:

1. How do we meet and satisfy the needs for group instruction?
2. What is the role of the programmed instruction to meet broad curriculum directives? and,
3. How do we combine the elements of programmed instruction in terms of meeting the realisms for a mass educational system?

I propose that programmed instruction be conceived of as a complete system of teaching, organized and designed to meet the specific objective of efficient individual learning.

I believe that the methods of programmed instruction as a system, provide the means for resolving the broad scope of instructional requirements which include the need for both individual and group instruction.

THE CONCEPT OF A SYSTEMS APPROACH

The terms system and systems approach when originally conceived, related to applied methods for increasing the efficiency of overall planning, organization, and coordination in the development of our national weapon systems.

The "systems approach" viewed the many individuals and groups developing a particular weapon (like the Atlas Missile) as individual components like cogs in a machine working together to achieve a common goal. This approach required (1) Defining in advance the job of each person or "cog" in terms of his assigned responsibilities: (2) Detailing the tasks: (3) Specifying performance requirements: and (4) Stating the necessary interactions and communications to be carried out between groups -- each requirement tailored and defined to meet the pre-set system goal.

The word system, therefore, suggests an organized plan, carried out in detail to achieve a pre-established goal or objective. The goal must be accomplished within set performance limits. Quality of performance is measured by the degree of compatibility or

efficiency between those components making up the system.

PROGRAMMED INSTRUCTION AS A SYSTEM

Now, let us apply the systems approach concept to programmed instruction. Here we are concerned with one common objective, namely, efficient individual learning and performance. In meeting this objective we can define three scopes of activity which are performed by independent groups. These groups are as follows: (Table I)

I. The Curriculum Director and the Programmer -- Analysing and developing instructional materials.

II. The Instructional Environment Consisting of the Teacher-Student Program Complex -- Carrying out the methods and procedures in the instructional process.

III. Administration, Supervisory, and Parental Groups -- While operating outside the immediate instructional environment directly, or indirectly, influence the quality of instruction and individual learning.

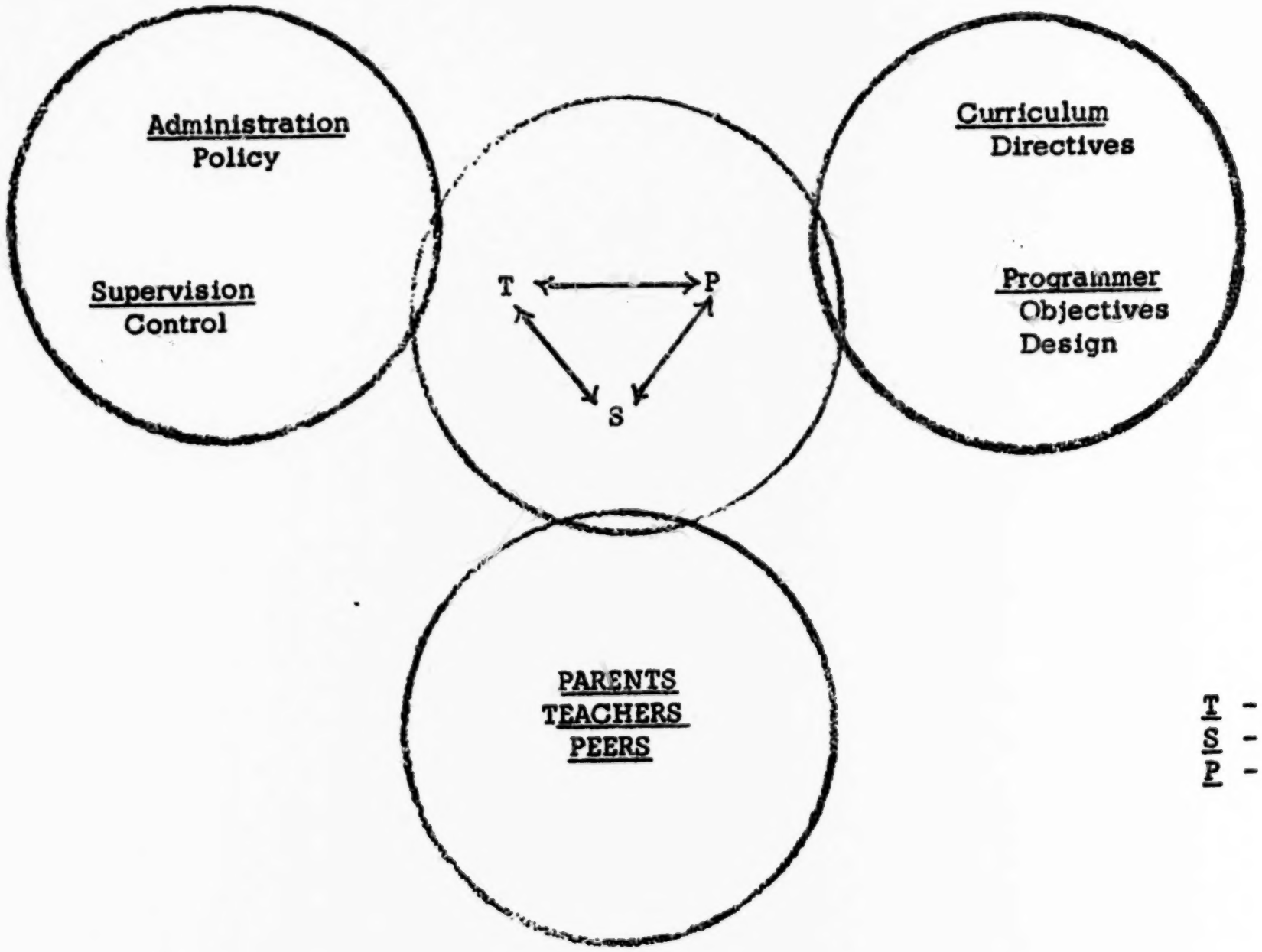
Each will be discussed separately.

THE PROGRAMMER AND HIS METHODS

The systems model is the contribution of the human factors or human engineering analyst. (Table II) He applies the systems approach (1) To establish design specifications for equipment, and (2) To establish operating and training requirements for the man operating the equipment. He must describe and predict performance for the man, design requirements for the machine. This method is called "Task Analysis". His prime objective is to insure that man and machine are compatible as a unified system.

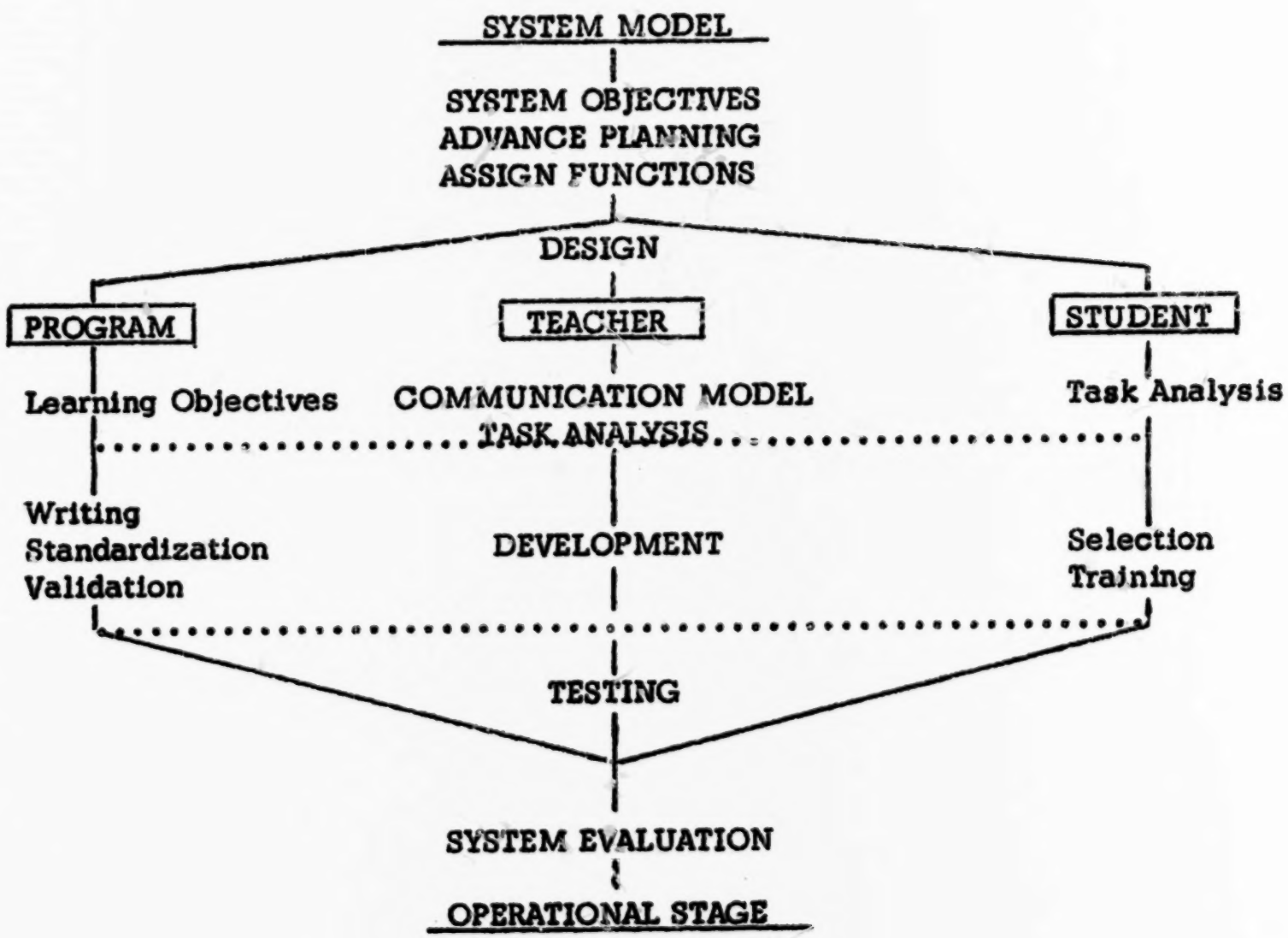
In an instructional system the "teacher-student-program complex" replaces the "man-machine" system. The programming analyst using the task analysis model follows a continual "try and fit" procedure to "tailor" a specific program or instructional package

TABLE I - PROGRAMMED INSTRUCTIONAL SYSTEM COMPONENTS



T - Teacher
S - Student
P - Program

TABLE II - PROGRAMMED INSTRUCTION AS A SYSTEMS MODEL



to meet defined instructional and learning objectives.

The problems confronting the programming analyst cover:

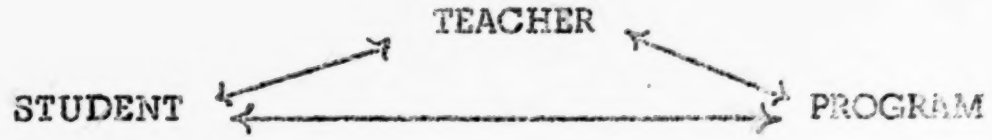
1. The curriculum directives and instructional requirements.
2. The learning requirements of the students.
3. The characteristics of the learner(s).
4. The instructional setting.
5. The models and methods of communication.

All these the programming analyst must consider while developing instructional materials.

THE INSTRUCTIONAL ENVIRONMENT:

TEACHER-STUDENT-PROGRAM COMPLEX

Individual achievement is the direct outcome of the interaction between the three prime sources which make up the immediate teaching-learning environment.



Each of the three elements (teacher, student & program) represent the contributing elements necessary to the instructional setting. While each can be considered alone, we define the teaching-learning process as a dynamic event with each element continuously interacting with the others in an ever-dependent relationship. The efficiency of teaching and/or learning is the direct outcome of the quality of the contribution of each of the three defined elements at the moment of their interaction. This is relevant whether we are referring to a student and a program, a student and a teacher, or any combination of these.

In this setting the contributions of the curriculum director, the programming analyst, and programmer are practically applied.

SYSTEM SUPPORT GROUPS

In analyzing instructional and learning processes we must consider all contributing elements influencing system efficiency. Our attention must be directed to the broadest scope to include groups outside the immediate instructional environment.

Viewing our educational system as an iceberg, the tip is representative of the immediate classroom. As with an iceberg, the greater supporting body is not directly observable. Yet, the supporting groups represented by administrative, supervisory and parental groups directly affect instruction and learning.

These non-observable, but highly significant supporting elements directly influence the quality and efficiency of instruction. It is imperative, therefore, that the role and contribution of each support group be defined to provide peak efficiency. Applying the common objective (student achievement) the required contribution of each can be analyzed and integrated into a comprehensive plan with means established for measuring the quality and efficiency of performance. The underlying guiding principle of the systems approach to education provides this vehicle.

These, then, are the distinct group and associated interdependent activities which must contribute compatibly to make the system work.

THE PROGRAMMED INSTRUCTIONAL SYSTEM:

ITS REQUIREMENTS AND SCOPE

Independent of system components or groups are the requirements and scope of the proposed instructional system. I should like to propose eight requirements of this system:*[1]

These are as follows: (Table III)

1. The statement of objectives for instruction and individual learning expressed in performance terms.

*[1] Expressed broadly in a policy statement by U.S.A.F. Headquarters, Washington, D.C. The stated requirements as originally presented have been modified and expanded.

TABLE III - P.I. SYSTEM

REQUIREMENTS	DESIGN CLASSIFICATION
1. STATEMENT OF OBJECTIVES	ORGANIZATION
2. ESSENTIAL SUBJECT MATTER	ORGANIZATION
3. ORDER MATERIAL IN STEPS	ORGANIZATION
4. ACTIVE STUDENT PARTICIPATION	COMMUNICATION & CONTROL
5. CONTROLLED PACING	COMMUNICATION & CONTROL
6. TWO-WAY COMMUNICATION	COMMUNICATION & CONTROL
7. APPLY LEARNING PRINCIPLES	EVALUATION
8. PERFORMANCE REQUIREMENTS - MEASURES	EVALUATION

2. The determination of the essential (minimal) subject matter to meet the stated objectives.

3. The ordering of subject matter into a program format designed to expedite the learning route.

4. Highly individualized student participation on a continuously active basis featuring the recurrent requirement for overt, observable responses to strengthen the learning process and to evaluate student achievement.

5. Controlled pacing of instruction consistent with student performance as measured by the pre-established criteria.

6. Highly directed communication by the "instructor" using the "tutorial" or "coach-pupil" two-way communication model to insure continual and purposeful interaction between "instructor and student".

7. Incorporation throughout the program of those fundamental principles essential to efficient learning, such as

   A. Knowledge of results of performance.

   B. Immediate correction of incorrect responses.

   C. Purposeful repetition and reinforcement scheduling.

   D. Directing the student in purposeful learning sequences with his knowledge of learning objectives present and future.

8. Statement of interim and final performance requirements and measures.

DESIGN CHARACTERISTICS OF THE SYSTEM

The design characteristics of the programmed system fall into three major classifications -- Organization, Communication and Control, and Evaluation.

Organization would deal with the underlying philosophy directing the system -- the analysis and planning for individual and group needs, and the selection of methods

to design materials to meet these defined needs. We would concern ourselves first with what is needed, second with which strategies of program construction should be used, and them consider how to complete the analysis and step sequences in the writing phases for either individual and/or group applications.

Communication and control is conceived of as primarily the teaching-learning process. Within this major classification is subsumed (1) Highly individualized active student participation, (2) The methods and model of communication employed, and (3) Those factors affecting the page and efficiency of the learning process.

In the evaluation of programmed materials we would be guided by the performance criteria specified during the planning and analysis phases. We would be concerned with the meeting of these performance criteria in terms of final or terminal student achievement and with program standardization during the validation phase. Within this framework we would consider (1) The underlying philosophy in the determination of performance measures, (2) The ways and means of specifying these measures, and (3) The meaning and use of terminal performance measures as final achievement tests.

THE SCOPE OF THE SYSTEM

The eight propositions or requirements provide a broad framework for an efficient system without restricting ways and means of implementation.

Regarding the scope of such a system, I make four assumptions: (Table IV)

FIRST -- That the application of the principles of programmed instruction is not restricted to self-paced or self-instructional materials, but can be extended to group instructional methods as long as the requirements are rigorously met.

SECOND -- That automated teaching or the use of teaching machines is not necessarily a contingency of programmed instruction. The discipline of programmed instruction can be applied advantageously to any educational or training situation and does not necessitate the automated or teaching machine process. However, within certain situations

TABLE IV - SCOPE OF P.I. SYSTEM

* SELF PACED
* GROUP PACED
  - A. CLASSROOM
  - B. MASS MEDIA
* ALL PROGRAM STRATEGIES
* TEACHING EQUIPMENT OPTIONAL

which both permit and warrant it, the process of automate teaching can be achieved. Thus, the two terms, programmed instruction and automated teaching are not, as commonly mistaken, synonomous. Programmed instruction is the system, while the use of teaching machines for self or group paced applications must be examined in terms of unique contribution to the efficiency of learning, instruction, or both, for the specific application.

A THIRD assumption is that mass media of communication, per se, are not necessarily eliminated. When we use such media as closed or open circuit television, motion pictures, tapes, film strips, etc., we are trans mitting information. If these media are modified to rigorously meet the stated requirements, they can be used to teach each individual within the group on a highly individual basis.

An important FOURTH assumption is that the proposed system does not limit methods or strategies of programming which now include linear, branching and mathetics. Each and all can be used advantageously and make unique contributions within the system. Neither environmental setting nor instructional application is limited providing that all the requisite criteria are met.

APPLICATIONS

These stated postulates can be applied to our existing instructional environment to accomplish optimal design of instructional sequences.

In fact, there are significant by-products to be derived from partial applications of the proposed system.

For example: Immediate benefits can be derived by applying the organizational principles to lesson planning procedures. (Table V) Lesson planning, as employed now, organizes the teacher in terms of subject matter coverage, and serves primarily as a guide.

In contrast, I propose that the lesson plan should be considered as a student learning blueprint with the prime design measure expressed in terms of student achieve-

TABLE V - COMPARISON OF LESSON PLANNING METHODS

CONVENTIONAL	PROGRAMMED
1. Teacher Oriented	1. Student Oriented
2. Subject Coverage	2. Performance Steps
3. Teacher Guide	3. Learning Blueprint
4. Instruction Objectives	4. Learning Objectives
5. Test Samples	5. Test Total Measure

ment. To be truly meaningful teaching objectives should be defined in terms of specific accomplishment - not subject matter coverage. Further, accomplishments should be defined in terms of student accomplishment - not teacher accomplishment. Applying the systems method the teacher would establish specific student learning objectives: Pre-state the methods and measures of student performance: and organize teaching steps to meet the learning objectives.

You might comment that what I am suggesting is that the teacher is simply teaching the final examination. That is exactly right! In this method, however, the final examination does not represent a sampling of the concepts taught (as does conventional testing), but, rather, demonstrates performance by the student(s) of pre-established achievement measures covering the complete and total defined criteria of learning.

Applications of this concept at Alamitos Intermediate School, Garden Grove, California, has resulted in significant advanced in the instructional and learning processes.

Let us examine the proposed concept that teaching and learning be considered primarily as a communication and control process.

In the conventional group setting the teacher most often applies the lecture or one-way communication model. Students play a passive role. The teacher proceeds according to his best "guestimate" of how well the information is understood, but knows what each student has learned?

For group instruction to be truly effective the lecture method must be replaced by the tutorial or two-way communication model. In this context, communication is defined as including three processes: (A) Sending, (B) Receiving, and (C) Understanding. Without the assurance that there is "understanding" of that which has been "sent" and "received" we cannot know whether we have communicated.

I am not proposing merely more question-answer interaction between teacher and student, but purposeful controlled questioning designed to test criteria measures.

Lowery Air Force Base evaluated the extensive use of classroom question-answer

techniques, allowing the students the freedom to stop the instructor during a presentation to ask questions. The results of this study (Table VI) indicated the following:

60% of the questions asked by students anticipated the instructor's presentation.

30% of the questions were completely irrevelant and seriously disrupted the instructional sequence.

Only 10% of the questions were meaningful and significant.

In summary, 90% of student questions disrupted the flow and pace of instruction without contributing to the individual learning process.

Teaching groups using the tutorial model of communication with programmed instruction implies that the program proceeds in a group-paced manner.

The obvious questions to this proposal are:

1. How does this take care of the problems of individual differences, and
2. How does group instruction using programmed methods affect the individual's rate of learning.

Charles Frye at Oregon College of Education, working under an N.D.E.A. grant, investigated ways to adapt self-instructional techniques to a group setting (Table VII). Frye assigned individuals to groups according to similarities in ability, experience, etc., to learn a self-paced program in mathematics. Material was presented to the experimental group on slides in a group-paced manner. He compared group-paced vs. self-paced methods for the same material. The results indicate that students of like or homogeneous ability perform as well working under group-paced conditions as they do working along at their own pace. Fry concludes that "only when there is a wide discrepancy in abilities within a group is there any likelyhood that learning rate will be retarded by forcing the learners to progress at the rate of the group. *2

*2 Frye, Charles H., Group vs. Individual Pacing in Programmed Instruction, Teaching Research, Oregon State System of Higher Education, Title VII, Project No. 847 National Defense Education Act of 1958.

TABLE VI - LOWERY QUESTION STUDY

STUDENTS QUESTION AT ANY TIME

QUESTIONS	*	60%	*	ANTICIPATING
	*	30%	*	IRRELEVANT
	*	10%	*	MEANINGFUL

90% DISRUPT WITHOUT CONTRIBUTING TO INDIVIDUAL LEARNING

TABLE VII - OREGON COLLEGE OF EDUCATION

CHARLES H. FRYE

GROUP VS. INDIVIDUAL PACING IN P.I.

Median Time In Minutes To Complete

PACING	HOMOGENEOUS	HETEROGENEOUS	DIFFERENCE
Group	255	325	70 *
Individual	221	240	19
	34	85 *	

* Statistically Significant ($P < .01$)

The form of communication model proposed for group instruction which meets all the stated system requirements for programmed instruction is a classroom communicator - such as the "Monitor-Teletest Communication."*[3] This system provides the capability for a teacher to program materials in carefully designed teaching steps according to the specifications stated. As an integral part of the teaching questions are posed to the class. Each student responds privately, is given immediate knowledge of the correctness of his response and has the ability to select the correct answer (if in error) before the group proceeds to the next question.

As the students respond, the teacher is given immediately the percentage of correct answers for the students' first response. In addition a continuous record of each student's performance is presented.

The Monitor-Teletest Communications System has been tried extensively at San Jose State College, University of Southern California, Alamitos School District, Garden Grove, California, and at the United States Air Force Academy. In the Air Force Academy program, two-way communication was extended to four classrooms over closed circuit television.

In every case the results show strikingly superior gains in the efficiency of instruction and individual learning when compared with conventional group instructional methods.

In the time permitted I would like to present in digest form the results of two research programs using the Monitor-Teletest System with group-paced programming methods in classroom instruction.

DIGEST 1

PLACE: San Jose State College, San Jose, California

INVESTIGATOR: Arthur Vicory

*3 MONITOR TELETEST COMMUNICATIONS SYSTEM will be manufactured and sold by Electronic Teaching Laboratories, Washington, D.C. under contract to CORRIGAN COMMUNICATIONS, INC., Santa Ana, California.

PROJECT: The role of student feedback (knowledge of results) in group-paced programming.

PROGRAM: "Development of Number Systems" -- Natural through complex numbers.

POPULATION: 87 college students

STANDARDIZATION: Step I: 15 individuals to 95% correct response on program.

Step II: 3 students in group - high, medium and low math aptitude.

EXPERIMENTAL DESIGN: Three experiments - one control group.

Experimental 45 min. of instruction	I.	Student response with feedback A. (Monitor-Teletest System)
	II.	Student response - no feedback A. Marked answers on IBM answer sheet.
	III.	No student response A. Conventional instruction
Control 250 min. of instruction	IV.	Conventional instruction in math course.
Criterion Test		43 questions measuring recall and problem solving given one week following instruction.

RESEARCH RESULTS:

1) Monitor-Teletest Group (with student response and feedback) performed significantly better than experimental groups responding without feedback and taught conventionally.

2) There is no significant difference between Group II student (responding but without feedback) and Group III (conventional instruction).

3) Control Group (taught in math course) was superior to all experimental groups. (250 minutes versus 45 minutes of instruction).

CONCLUSIONS (VICORY):

1) Passive student response without feedback has no significant effect on learning.

2) Active student response with feedback reinforces learning and performance beyond limits of math program, per se.

DIGEST II

PLACE: University of Southern California, Los Angeles

INVESTIGATORS: Harold Sluth and William Deutsch

PROJECT: Comparison of group-paced programmed instruction with student feedback and response versus conventional instruction (no programming--no student response).

PROGRAM: Principles and use of projection systems.

POPULATION: 65 college students.

EXPERIMENTAL DESIGN:

Two Control Groups: A. Two hour instruction period. One hour lecture: One-half hour demo: One-half hour lab.

B. No student responding or feedback.

EXPERIMENTAL GROUP: A. One hour group-paced program covering identical material.

B. Student responding with feedback.

EXPERIMENTAL CONTROLS:

A. Control instructors shown in advance programming objectives to insure same instructional goals both C & E group.

B. Instructor qualified and experienced.

CRITERION TEST: Standardized 76 True-False examination given two days after instruction.

RESEARCH RESULTS:

1) Experimental group using Monitor-Teletest System performed 20% higher in achievement tests than control groups.

2) No differences reported between control groups.

3) 100% savings in time of instruction (one hour) using group-paced programmed methods with student responding with feedback.

The experimental results for the Alamitos Intermediate School show equally striking results using Monitor-Teletest with group-paced programming. With the Monitor-Teletest Communications System group instruction becomes a highly individualized learning experience for the student -- and the teacher.

COMBINING SELF AND GROUP PROGRAMMING METHODS

The United States Air Force Academy has developed a complete instructional system combining the elements of self-paced and group-paced programmed instruction. Group-paced instruction is accomplished by combining the Monitor-Teletest System with closed circuit television (mass communication). A two-way communication network is provided between students in four classrooms and the television teacher in the studio. The system gives the teacher immediate knowledge of the level of understanding indicated by students and the rate at which problem solving is accomplished. With this knowledge the teacher controls the level of complexity of instruction and the pace consistent with student needs. Students in turn are provided immediate feedback and reinforcement. As used in this application the Monitor-Teletest System becomes a teacher-paced system.

Following the televised instruction, students work on self-paced materials followed by practical problem solving tasks applying concepts learned. This sytems model of programmed instruction should be significantly interesting to educators. The results have been of great significance to the academy.

OTHER SYSTEM APPLICATIONS

One of the questions posed by educators is: What is the role of the self-instructional program (s) in broad curriculum directives?

Combining self-instructional materials in the school system have taken other forms than applying individual instruction in place of group methods.

Two studies in particular, Teaching Machines, Inc., and A.I.R. indicate the significant advance in individual learning and achievement when self-paced programs are used as homework assignments. Significant contributions are reported in overall individual learning efficiency and student motivation when self-instructional programs are integrated into the instructional system in this manner.

SUMMARY

I have proposed that programmed instruction be conceived of as a formal instructional system best suited and designed to meet the ultimate objective of our educational system -- efficient individual learning and performance.

System requirements are postulated to organize and develop the methods and materials of instruction most consistent with efficient individual learning requirements in both individual and group settings.

I have further proposed that the underlying philosophy of this system provides the most meaningful rationale to organize, coordinate and direct the efforts of all contributing groups. Applying the proposed systems concept provides a "team approach" with specification of the role and performance requirements for each team member consistent with the established objectives of instruction.

TABLE VIII - RESEARCH RESULTS - MONITOR-TELETEST

SAN JOSE STATE COLLEGE

POSSIBLE SCORE = 100 % CORRECT

(During Prog.)	Criteria Questions		
	GROUP I (Student Feedback) N = 24		Students Respond Group-Paced Programming
Mean	85.83	66.11	
S.D^2	52.71	26.21	
	GROUP II (No Student Feedback) N = 22		
Mean	80.64	62.27	
S.D^2	64.01	42.16	
	GROUP III (No Student Responding) N=20		Conventional Lecture Methods III - 45 min. IV - One week in course
Mean		61.21	
S.D^2		64.80	
	GROUP IV (No Student Responding) N = 21		
Mean		72.57	
S.D^2		115.56	

TABLE IX - RESEARCH RESULTS - MONITOR-TELETEST

UNIVERSITY OF SO. CALIFORNIA

* STUDENTS RESPONDING WITH FEEDBACK

20% Increased Test Achievement
Over Both Control Groups ($P < .01$)

* NO DIFFERENCES BETWEEN CONTROLS

* 100% SAVINGS IN INSTRUCTION TIME

Using Group Paced Programming
With Monitor-Teletest System